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Individual Adaptation: Performance in a Changing Context

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INDIVIDUAL ADAPTATION: PERFORMANCE IN A CHANGING CONTEXT

by

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DEDICATION

I dedicate this dissertation to my loving family. This would not have been possible without their unconditional love and support. I would specifically like to thank a man for whom I have tremendous respect, my father. I appreciate his dedication and loyalty more than words could ever express. I would also like to express my gratitude to Dr. William O. Dwyer for being both my mentor and advocate. This would not have been possible without his guidance and support.

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ABSTRACT

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This study examined the relationship between individual differences (Cognitive Ability, Conscientiousness, Openness to Experience) and the ability to maintain performance on a changing task. Participants included 69 college students at a southeastern university. Participants were trained to operate the Distributed Dynamic Decision Making (DDD), a computer-based simulation. All analyses were conducted at the individual level. Results indicated that Cognitive Ability predicts performance across varying levels of workload on the DDD task. The results further indicate a significant interaction between Cognitive Ability and Conscientiousness. The hypothesized relationship between performance and Openness to Experience, however, was not supported. The practical implications, limitations and directions for future research are discussed.

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Introduction

Individual Adaptation: Performance in Changing Context

"The only thing constant in life is change"

-François de la Rochefoucauld

The importance of individuals' ability to adjust to the inevitable changes in their environment has been highlighted as a critical element of survival. Charles Darwin (1859) insisted that it is not the strongest of the species that survives, nor the most intelligent, but rather the one most responsive to change. Much like the survival of species, organizational longevity in today's market is highly dependent on how people respond to environmental changes. Researchers depict the current labor market and corresponding organizational structures as dynamic and ever changing systems (Edwards & Morrison, 1994; Hollenbeck, LePine, & Ilgen, 1996; Ilgen & Pulakos, 1999; Smith, Ford, & Kozlowski, 1997). The ability to respond in an adaptive manner is particularly relevant in today's society due to the development of new technologies and the increasingly complex nature of work. As the Department of Labor noted, "employment growth rates have varied widely among industries as changing demand, technology and global competition have reshaped the labor market"(Department of Labor, 2006, p. 12).

Background

Tighter economic resources over the last 25 years have led to intense organizational competition. To achieve their business purpose, organizations require a highly skilled workforce. To acquire such a workforce, an organization's selection system must be able to identify those potential employees with the necessary knowledge, skills, and abilities (KSAs) who can contribute to organizational success. As the work

environment evolves, productive employees must be able to adapt to these changes. To remain competitive, organizations must be capable of quickly identifying changes in their environment and altering their strategies to accommodate these changes without compromising performance (Entin & Serfaty, 1999; LaPorte & Consolini, 1988). This is especially true in military organizations because they typically operate in such volatile environments. To sustain acceptable performance, one must be able to "cooperate and improvise in unpredictable circumstances," (Sundstrom, De Meuse, & Futrell, 1990, p. 121). Kozlowski, Gully, Nason, and Smith (1999) assert that adaptability is a critical component for performance in many military organizations.

As reflected in the Quadrennial Defense Review Report (2006), the US Military faces continually changing conditions that require greater agility, flexibility, and adaptability. As a result, the military has become increasingly interested in attracting men and women who are capable and willing to work in a changing environment. In fact, consultants and other experts in this area have begun advising the United States Army to sharpen its focus on adaptability in its selection and training efforts (Department of the Army, 2001; Tillson et al., 2005). The ability to discriminate and successfully select individuals who are capable of performing adaptively in extreme environments is a significant advantage, particularly in military settings (Burke, Stagl, Salas, Pierce, & Kendall, 2006).

One example of an organization that relies on identifying and selecting capable employees is the United States Navy. Like many other organizations, the Navy is facing change on a variety of fronts. Technological advances increase demands on performance in the military, which in turn emphasizes the importance of selecting sailors who are able

to maintain acceptable levels of performance in the face of unforeseen difficulties and novel circumstances. Currently, the Navy is working to man the future Littoral Combat Ships (LCS) that require fewer, more versatile sailors capable of adapting to the unanticipated changes within this new type of work environment. Given the variety of changes to the Navy's operating environment, research is required to understand how various factors can predict an individual's ability to perform adaptively.

Defining Adaptability

In recent years, research on adaptability has grown considerably. In fact, within the last decade several areas of research have begun to make significant progress in furthering our understanding of adaptability in the workplace. Researchers have offered a variety of formal definitions of adaptability (see Table 1) (Banks, Bader, Fleming, Zaccaro & Barber, 2001; Bell & Kozlowski, 2002, 2008; Chan, 2004; Chen, Thomas, & Wallace, 2005; Cronshaw & Jethmalani , 2005; Fine & Cronshaw, 1999; Ivancic & Hesketh, 2000; Joung, Hesketh, & Neal, 2006; Keith & Frese, 2005; Kozlowski et al., 2001; Kozlowski et al., 2001; Meneely & Portillo, 2005; Mueller-Hanson, Swartout, Hilton, & Nelson, 2009; Polyhart & Bliese, 2006; Pulakos, Arad, Donovan, & Plamondon, 2000; Pulakos et al., 2002; Scaduto, Lindsay, & Chiaburu, 2008; Smith et al., 1997).

Table 1

Definitions of Adaptive Performance

Source	Definition
Smith, Ford, & Kozlowski (1997)	Skill generalization in response to novelty. Adaptability is evidenced when the individual responds successfully to changes in the nature of the trained task.
Fine & Cronshaw (1999); Cronshaw & Jethmalani (2005)	Competencies that enable people to manage themselves in relation to the demands of conformity and/or change in particular situations.
Ivancic & Hesketh (2000); Keith & Frese (2005)	Using one's existing knowledge base to change a learned procedure, or to generate a solution to a completely new problem
Pulakos, Arad, Donovan, & Plamondon (2000); Pulakos, Schmitt, Dorsey, Arad, Hedge & Borman (2002)	Situations in which individuals modified their behavior to meet the demands of a new situation, event, or a changed environment.
Kozlowski, Gully, Brown, Salas, Smith, & Nason (2001); Kozlowski et al. (2001); Bell & Kozlowski (2002, 2008)	The generalization of trained knowledge and skill to meet the demands of novel and more difficult, complex and dynamic situations.
Chen, Thomas, & Wallace (2005)	The capability to modify knowledge, skill and other characteristics acquired during training to effectively meet novel, difficult, and complex situations.
Meneely & Portillo (2005)	Creative adaptation involves flexibility in thinking, responsiveness to environment (self-adaptation), and transformation and evolution of the environment.
Joung, Hesketh, & Neal (2006)	An individual's capacity to deal with changing work requirements and novel or unusual situations.
Polyhart & Bliese (2006)	An individual's ability, skill, disposition, willingness, and/or motivation to change or fit different task, social, and environmental features.
Scaduto, Lindsay, & Chiaburu (2008)	Adaptation is defined as the transfer and generalization of trained skills to new or more complex task situations (e.g., to their job).

In spite of the variations, most of these definitions share in common the notion that adaptability involves an effective behavioral adjustment in response to a change, or anticipated change, in environmental circumstances. Research studies on adaptation

typically operationalize changes in the task environment in terms of an increase in complexity (e.g., Chen, 2005; Kozlowski et al., 2001; LePine, 2003, 2005; LePine, Colquitt, & Erez 2000; Marks Zaccaro, & Mathieu, 2000) because such increases are generally considered to be the more frequent adaptive scenario in occupational settings and are also more difficult to master (LePine, 2005). With respect to research paradigms, a number of studies in laboratory settings unpredictably overload participants with workload to induce stress (Chen, 2005; DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004; Ellis, 2006; Entin & Serfaty, 1999).

Predictors of Individual Adaptability

To create an adaptive workforce, organizations must select people with characteristics predictive of the ability to engage in adaptive performance (e.g., cognitive capabilities, being open to new experiences). Past research suggests that some individuals may be inherently more adaptable than others. It has been only within the last ten years that researchers on adaptation have begun to investigate and identify some of the factors that underlie and influence an individual's ability to perform adaptively (Kozlowski & Rench; 2009). Despite the fact that this area of research is in its early stages of development, several trends have emerged.

In particular, these individual differences include Cognitive Ability (Bell & Kozlowski, 2002, 2008; Holladay & Quinones, 2003; LePine, Colquitt, & Erez 2000; Pulakos et al., 2002; Kozlowski et al., 2001; Zaccaro, 2001a), Conscientiousness (Dalton & Wilson, 2000; Davis, Fedor & Parsons, 2002; Mount, Barrick, Strauss, 1999), and Openness to Experience (Davis et al., 2002; LePine et al., 2000; Pulakos et al., 2002; Zaccaro 2001a).

Non-Cognitive Predictors

Previous research suggests openness to experience is positively related to decision-making performance and more strongly so after a contextual change in TIDE2 (Hollenbeck et al., 1995), a computer simulation game that forces an adaptive response (LePine et al., 2000). More specifically, LePine et al. (2000) found that those with higher levels of Openness to Experience perform better r = -.35 (p < .05) after a radical change in situational demands. The results of LePine and colleagues (2000) can be interpreted to suggest that those individuals more open to new experiences are less likely to become entrenched in routines and are more accepting of novel solutions to problems. Consistent with these findings, Pulakos et al. (2002) also found higher levels of Openness to Experience as measured by the Personal Styles Inventory (PSI; author developed) to be predictive of supervisory ratings across 21 different jobs requiring adaptability r = .04 (p < .05). Within the same study, Pulakos also found the achievement facet of Conscientiousness to be positively correlated r = .31 (p < .05) with supervisor ratings of individual performance in jobs requiring varying levels of adaptability. These findings were in contrast with LePine's earlier research in 2000 that established a negative relationship between participants' level of conscientiousness and performance r = -.29 (p < .05) (i.e., lower scores indicating higher performance) after a radical change in situational demands within the TIDE2 simulation task (Hollenbeck et al., 1995).

Thus, Pulakos et al. (2002) and LePine et al. (2000) identified the same two personality characteristics as predictors of adaptability: Openness to Experience and Conscientiousness. Both studies found Openness to Experience to be positively correlated with adaptability. However, Pulakos et al. (2002) found a positive correlation

between Conscientiousness and adaptability, whereas LePine et al. (2000) found a negative relationship. These inconsistencies require further research to clarify how these two personality characteristics relate to individual adaptability.

Cognitive Predictors

Past research supports the idea that individual differences in cognitive ability can play a significant role in task performance (e.g., Cuevas, Fiore, Bowers, & Salas, 2004; LePine, Hollenbeck, Ilgen, & Hedlund, 1997; Offerman, Bailey, Vasilopoulos, Seal, & Sass, 2004). The link between cognitive ability and individual task performance has also been extended to performance on changing or adaptive tasks (Bell & Kozlowski, 2002, 2008; Holladay & Quinones, 2003; Kozlowski et al., 2001; LePine et al. 2000; Pulakos et al., 2002; Zaccaro, 2001a). The most recent of these studies was conducted by Bell and Kozlowski (2008) on an undergraduate sample using the TANDEM task (Weaver et al., 1995), a computer simulation game. This research found a significant relationship $r = .31$ ($p < .01$) between an individual's level of Cognitive Ability, as measured by SAT/ACT scores, and subsequent skill generalization (operationalized as training performance).

After decades of research findings supporting the benefits of Cognitive Ability, recent investigators in the literature have begun to argue a rather counterintuitive claim that higher levels of general cognitive ability may actually impair performance on complex tasks. These recent claims that "less is more" are certainly provocative. For example, recent studies have found that inducing pressure in performance situations is more detrimental to higher-ability performers than to their lower-ability counterparts (e.g., Beilock & Carr, 2005) and, conversely, that those lower in working memory capacity experience "success under stress" (Beilock & DeCaro, 2007, p. 983). Other

seemingly paradoxical results have also surfaced, namely that on complex categorization tasks, those higher in working memory tend to over-think and perform worse than those lower in working memory (DeCaro, Thomas, & Beilock, 2008), or more generally that those with higher levels of Cognitive Ability have more difficulty than those with lower Cognitive Ability when adapting to changes in complex task environments while acquiring a skill (Lang & Bliese, 2009).

Among other objectives, this paper investigates the idea that "less is more" by examining the relationship between General Mental Ability and individuals' ability to perform a complex and changing task environment. With respect to the relevance of Conscientiousness and Openness to Experience these contradictory results also suggest a need for additional empirical investigation.

The Current Study

The overall purpose of the study was to assess the degree to which General Mental Ability, Conscientiousness and Openness to Experience may be associated with the ability to engage in successful adaptive behavior in a simulation environment that is undergoing change. Specifically, individuals were trained to use a computer simulation game, after which they completed two scenarios: (1) one under routine conditions, and (2) and one under adaptive (changing) conditions. In the second scenario, participants were systematically introduced to higher levels of workload and/or changes in the demands. Participants' performance during the routine condition was compared with their performance during the adaptive condition. Differences in performance across the two condition types (i.e., routine, adaptive) served as the dependent measure of adaptive performance ability. In addition to completing tasks in the simulated environments,

participants were asked to complete a battery of tests measuring Cognitive Ability and the two personality traits of Conscientiousness and Openness to Experience. These three particular psychological constructs and their respective measures were selected from the literature because they have shown promise in previous studies. Specifically, the three hypotheses below were investigated:

Hypotheses

H1: A positive relationship exists between level of Cognitive Ability and performance in the adapt condition.

H2: A positive relationship exists between level of Conscientiousness and performance in the adapt condition.

H3: A positive relationship exists between Openness to Experience and performance in the adapt condition.

Method

Participants

The participants consisted of 69 undergraduate student volunteers, of whom 72% were female and 28% were male. Participants were recruited from a large southeastern university via subject pool flyers posted around campus (see Appendix A). Participants were monetarily compensated for their time and/or received course credit, as appropriate.

Measures and Instrumentation

Participants completed a battery of self-report measures to assess the cognitive and personality variables under consideration. Participants' scores on a computer-delivered version of Raven's Progressive Matrices (Raven, 1938) were used to measure their Cognitive Ability. For this test of General Mental Ability (GMA), participants were asked to select a figure that best completes a logical pattern of figures displayed on the computer screen.

The International Personality Item Pool (IPIP) was used to assess participants' levels of Conscientiousness and Openness to Experience (Goldberg, 1999). The International Personality Item Pool is an internet-housed item bank in the public domain (Goldberg, 1999) that contains 300 items representing an IPIP version of Costa and McCrae's NEO-PI-R (1992). In addition, the 10-item short form measure developed from the 33-item Marlowe-Crowne Scale (Crowne & Marlowe, 1960) was used to assess participants' level of Social Desirability (Strahan & Gerbasi, 1972).

Software. Participants operated a computerized simulation game known as the Distributed Dynamic Decision Making (DDD), a modified version of a simulation developed for the Department of Defense, (DDD; Miller, Young, Kleinman, & Serfaty, 1998). The task environment was divided into three geographic sectors (see Appendix B). Within a given session, each sector was assigned to one of three participants. Participants were randomly assigned labels (i.e., A, B, or C) according to their respective sector. The three sectors varied in terms of the extent to which they needed to be protected from unfriendly planes. The overall goal of each mission was to keep unfriendly planes from moving into the restricted areas, while allowing friendly planes to freely move in and out

of the same areas. All planes originated from the edge of the screen and proceeded inward. Once a plane came within the identification range, the participant responsible for that sector would identify the type of plane (i.e., friendly or enemy), tag and then shoot it down if necessary. Performance data were recorded in terms of the number of planes correctly shot down. The simulation was designed to be played by three team members working together and sharing information, the purpose being to examine team performance under changing levels of workload (i.e., increase in number of planes within a given sector). However, for this study the level of interaction or coordination among team members to resolve the changing task demands was quite minimal. In other words, the amount of aid either solicited or given by any team member was not consistent or sufficient to constitute analysis at the team level. As a result, this study examined performance data at the individual level.

Procedure

The present study was divided into two separate phases. Phase I consisted of two laboratory sessions during which the participants filled out the informed consent (see Appendix C) and completed a test battery (see Appendix D). Phase II consisted of seven laboratory sessions using the DDD simulation task. In Phase II, participants were trained to use the DDD simulation, after which they completed two types of scenarios: (1) one under routine conditions, and (2) one under adaptive conditions. Further details regarding the conditions in Phase II are provided below.

Training. During the third session, participants received training on how to navigate the DDD software environment. Specifically, they were instructed on how to move their tanks, transfer a tank, and shoot down enemy planes. Participants were then

presented with 5 planes each to practice their game relevant skills (i.e., moving tank, shooting down enemy planes) in the simulation environment.

Routine Condition. During the fourth session, participants experienced routine conditions in which they were presented with 49 planes each. The routine condition presented a low workload (i.e., lower number of planes as compared to the adaptive condition) and was used to assess participants' baseline performance.

Adaptive Condition. In the adaptive condition, the workload in a specified sector(s) would unexpectedly increase from 48 to 72 enemy planes. In addition to an increase in enemy planes; the range of visibility for each participant was restricted for the adaptive condition. The reduction in visibility made it more difficult for each participant to detect incoming planes and shoot down planes outgoing planes. As a result, participants were required to shoot down more enemy planes, with less detection time to maintain acceptable performance.

Performance scores for each condition were calculated using two computer-generated outputs for each performance scenario. The dependent measure of participant adaptation was operationally defined as the percentage of task accuracy (i.e., percentage of planes successfully shot down out of total planes) with higher scores indicating better performance. Scores on each self-report measure were then correlated with the number of planes shot down in the routine and adaptive performance conditions. The difference score was an additional variable created to assess any changes in participants' performance from the routine to adaptive conditions. This score was calculated by subtracting the performance score on the routine condition from their performance score

on the adaptive condition. The correlations between the difference scores and participants' self-report measures were also assessed.

The present research employed a between-subjects design. As previously stated, participants signed an informed consent, completed a test battery and were then randomly assigned to be player A, B, or C in Phase I of this study. In Phase II, participants were trained to use the DDD simulation task. In the following session, all participants (i.e., A, B, C) experienced the DDD simulation task under routine conditions. The order in which each player A, B, and C experienced the adaptive condition on the DDD simulation varied. For example, participant B experienced the adaptive condition in the third session of Phase II. Participant C experienced the adaptive condition in the fourth session and A in the fifth session of Phase II (see Table 2). Additional details regarding the study design are discussed below. For purposes of the primary analyses focusing on adaptation, the main dependent variable consisted of the participants' scores the first time they experienced an adaptive (i.e., increased planes) condition.

As Table 2 indicates, participants were also presented with a subsequent session during which they were again confronted with the increased-planes condition. Although not directly related to the study's main hypotheses, this second session provided data on the degree to which additional practice effects may have been present.

Table 2

Experimental Design by Phase, Session, Task and Player

Phase	Session	Condition	Task	Player
I	1	---	Test Battery Part 1	---
I	2	---	Test Battery Part 2	---
II	3	Training	DDD Simulation	ABC
II	4	Routine	DDD Simulation	ABC
II	5	Adapt	DDD Simulation	B
II	6	Adapt	DDD Simulation	C
II	7	Adapt	DDD Simulation	AB
II	8	Adapt	DDD Simulation	AC
II	9	Adapt	DDD Simulation	A

Results

Survey data were analyzed using SPSS 16.0, a statistical software package. All relevant assumption testing was performed prior to testing the three hypotheses. Using a criterion of z-scores greater than 2.5 or less than -2.5 there were no outliers on either independent or dependent variables (Meyers, Gamst, & Guarino, 2006). Finally, the assumption of normality was not violated according to the Shapiro-Wilks test ($p < .001$).

Test for Practice Effects

As previously mentioned, the order in which each participant experienced the adaptive condition was not randomly assigned. As a result, the amount of practice or experience each participant had in the adaptive condition varied, depending on whether he or she was assigned to the A, B, or C groups. Thus, before conducting further

analyses, it was important to determine if the order in which these groups experienced the adaptive condition did, in fact, influence their performance during the adaptive sessions.

To examine this issue, two One-Way ANOVAs were conducted comparing the mean performance scores of players in the A, B, and C groups on the routine (see Table 3) and adapt conditions (see Table 4). The results of this analysis indicated that there were no significant differences among their mean performance scores on the either the routine F (2, 66) = .698, p = .501 (see Table 5) or adapt condition F (2, 66) = 2.29, p = .109 (see Table 6). In turn, the aforementioned results suggest that aggregating all participant groups (i.e., A, B, C) into one category would be appropriate for the subsequent statistical analyses.

Table 3

Descriptive Statistics for Performance by Group in the Routine Condition

	Variable	*N*	*M*	*SD*
1.	Participant Group A	23	.38	.172
2.	Participant Group B	23	.38	.173
3.	Participant Group C	23	.32	.190

Note. Higher scores indicate better performance.

Table 4

Descriptive Statistics for Performance by Group in the Adapt Condition

Variable	*N*	*M*	*SD*
1. Participant Group A	23	.40	.178
2. Participant Group B	23	.46	.179
3. Participant Group C	23	.35	.183

Note. Higher scores indicate better performance.

Table 5

Between Subjects ANOVA for Performance in the Routine Condition

Source	*Sum of Squares*	*df*	*MS*	*F*	*p*
Between Groups	.045	2	.022	.698	.501
Within Groups	2.112	66	.032		
Total	2.157	68			

Table 6

Between Subjects ANOVA for Performance in the Adapt Condition

Source	*Sum of Squares*	*df*	*MS*	*F*	*p*
Between Groups	.149	2	.075	2.29	.109
Within Groups	2.151	66	.033		
Total	2.301	68			

Relationship Among Constructs

Descriptive statistics for the IPIP subscales and other variables of interest were assessed. The Ns, means, standard deviations, and correlations among the subscales and dependent measures are presented in Table 7. Reliability was assessed for Openness to Experience (α = .81), Conscientiousness (α = .84), Raven's Progressive Matrices (α = .96), and Social Desirability (α = .97).

As Table 7 indicates, there are several significant correlations among the subject variables. With respect to their relationship to the dependent variables, only Cognitive Ability demonstrated significant correlations with performance in both the routine and adaptive conditions. These findings provide support for Hypothesis 1, but not for Hypotheses 2 and 3. Performance scores in the routine and adapt conditions were positively correlated with each other. Furthermore, the delta, or change, scores from the routine to the adapt conditions were positively correlated with performance in the routine condition and negatively correlated in the adaptive condition. With respect to the subject

variables, themselves, the only positive correlation was between Openness and Conscientiousness. Interestingly, there was one negative correlation between GMA and Conscientiousness. Finally, a positive correlation between the Openness to Experience subject variable and Social Desirability was observed.

Test of Hypotheses

As a further examination of the hypotheses, and to check for any interactions, participants were divided by median splits based on their Cognitive, Conscientiousness and Openness scores. Using these groups, two One-Way ANOVAs were conducted, with the routine and adapt score, respectively.

Routine condition. As expected from the correlation data reported above, the results of this analysis revealed a main effect for Cognitive Ability and performance, as measured by the percentage of planes shot in the routine condition F (1, 69) = 4.776, p = .003. In other words, participants higher on Cognitive Ability performed better on the routine condition (M = 40) compared to the performance of those with lower ability (M = 33). An interaction between Cognitive Ability and Conscientiousness was also observed in the routine condition F (1, 69) = 4.93, p = .030 (see Table 8). Specifically, the interaction showed that the low Cognitive Ability (GMA), high Conscientiousness group performed significantly worse than all other groups on the routine condition. See Figure 1 for an illustration of this interaction. No other interactions or main effects were observed for the routine condition.

Table 7

Ns, Means, Standard Deviations, and Intercorrelations Among Variables

	1.	2.	3.	4.	5.	6.	7.
1. General Mental Ability	_						
2. Conscientiousness	-.258*	_					
3. Openness to Experience	-.053	.290*	_				
4. Social Desirability	.013	.205	.250*	_			
5. Routine Condition	.311**	-.137	-.067	.077	_		
6. Adapt Condition	.332**	-.043	.104	.034	.602**	_	
7. Difference Score	-.035	-.102	-.191	.046	.417**	-.475**	_
N	69	69	69	69	69	69	69
M	33.80	218.07	210.91	15.67	.364	.408	-.04
SD	13.71	28.38	20.93	1.78	.178	.183	.162

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed.

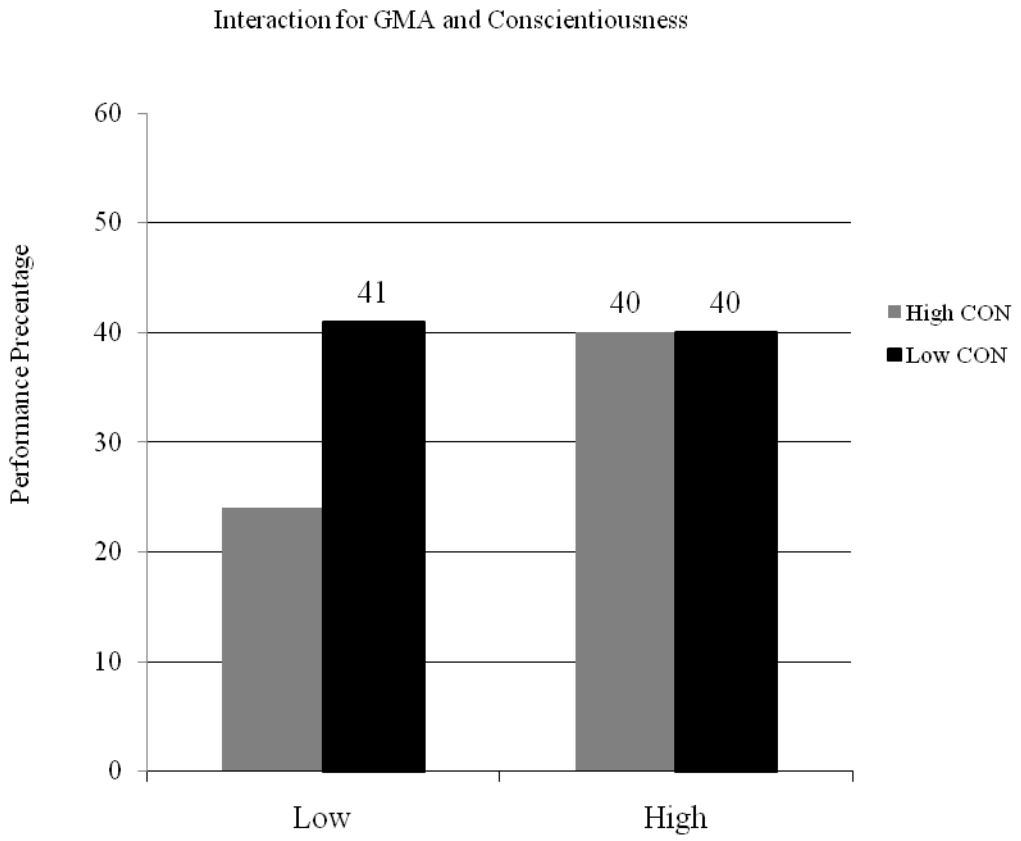

Figure 1. Interaction between GMA and Conscientiousness F (1, 69) = 4.9356, p = .030.

Table 8

Between Subjects ANOVA for Performance in the Routine Condition

Source	*Sum of Squares*	*df*	*MS*	*F*	*p*
GMA	.134	1	.134	4.776	.033**
CON	.107	1	.107	3.803	.056
OPN	.002	1	.002	.061	.805
GMA * CON	.139	1	.139	4.939	.030**
GMA * OPN	.009	1	.009	.306	.582
CON * OPN	.022	1	.022	.785	.379
GMA * CON * OPN	.036	1	.036	1.288	.261
Error	1.714	61	.028		
Total	11.331	69			

Note. * $p < .05$. ** $p < .001$, two-tailed.

Adaptive Condition. A main effect for Cognitive Ability and performance as measured by the percentage of planes shot in the adapt condition was observed F (1, 69) = 6.134, p = .016. More specifically, participants higher in Cognitive Ability also performed better on the adapt condition (M = 46) when compared to those of lower ability (M = 36). No other main effects or interactions were observed for the adapt condition (see Table 9).

Table 9

Between Subjects ANOVA for Performance in the Adapt Condition

Source	*Sum of Squares*	*Df*	*MS*	*F*	*p*
Between Groups GMA	.198	1	.198	6.134	.016**
CON	.031	1	.031	.974	.328
OPN	.007	1	.007	.211	.648
GMA * CON	.056	1	.056	1.74	.192
GMA * OPN	.003	1	.003	.081	.777
CON * OPN	.039	1	.039	1.210	.276
GMA * CON * OPN	.007	1	.007	.227	.635
Error	1.973	61	.032		
Total	13.809	69			

Note. * $p < .05$. ** $p < .001$, two-tailed.

Additional Analyses

To further investigate the interaction between GMA and Conscientiousness, an additional variable for group was created. The group variable divided participants into four different groups according to their level (i.e., high, low) of GMA and Conscientiousness. The first group was labeled LL, and consisted of participants with low GMA, and low Conscientiousness. The second group was labeled LH, and consisted of participants with low GMA and high Conscientiousness. The third group was labeled HL, and consisted of participants with high GMA and low Conscientiousness. Finally, the fourth group was labeled HH and consisted of participants with high GMA and high

Conscientiousness. Using these groups, two additional analyses were conducted to determine if there are any differences in performance as a function of group.

Post Hoc Analysis

To further examine the interaction previously mentioned, two separate One-Way ANOVAs were conducted comparing the mean performance scores of players in Groups 1, 2, 3 and 4 respectively, on the routine (see Table 10) and adapt conditions (see Table 11). The results of the first analysis revealed a main effect for group and performance on the routine condition F (3, 65) = 4.585, p = .006 (see Table 12). Specifically, post-hoc analyses revealed that players in the low GMA, high Conscientiousness Group (i.e., Group 2) performed significantly ($p < .05$) worse than all other groups in the routine condition. The second analysis contrasting the mean performance in the adapt condition also revealed a main effect for Group and performance F (3, 65) = 2.922, p = .040 (see Table 13). Subsequent post-hoc analyses revealed that, again, players in the low GMA, high Conscientiousness Group (i.e., Group 2) performed significantly worse ($p < .05$) in the adapt condition than players in the High GMA, High Conscientiousness Group (i.e., Group 4). Figure 2 provides an illustration of performance across both conditions for the four groups mentioned above.

Table 10

Descriptive Statistics for Performance by Group in the Routine Condition

	Variable	*N*	*M*	*SD*
1.	Participant Group 1	18	.42	.198
2.	Participant Group 2	17	.24	.126
3.	Participant Group 3	17	.40	.175
4.	Participant Group 4	17	.40	.149

Note. Group 1= Low GMA, Low Conscientiousness, 2 = Low GMA, High Conscientiousness, 3 = High GMA, Low Conscientiousness, 4 = High GMA, High Conscientiousness

Table 11

Descriptive Statistics for Performance by Group in the Adapt Condition

	Variable	*N*	*M*	*SD*
1.	Participant Group 1	18	.41	.196
2.	Participant Group 2	17	.31	.153
3.	Participant Group 3	17	.45	.176
4.	Participant Group 4	17	.47	.176

Note. Group 1= Low GMA, Low Conscientiousness, 2 = Low GMA, High Conscientiousness, 3 = High GMA, Low Conscientiousness, 4 = High GMA, High Conscientiousness

Table 12

Comparison of Performance in the Routine Condition by Group

Source	*Sum of Squares*	*df*	*MS*	*F*	*P*
Between Groups	.377	3	.126	4.585	.006**
Within Groups	1.178	65	.027		
Total	2.157	68			

Note. * $p < .05$. ** $p < .001$, two-tailed.

Table 13

Comparison of Performance in the Adapt Condition by Group

Source	*Sum of Squares*	*df*	*MS*	*F*	*p*
Between Groups	.273	3	.091	2.922	.040**
Within Groups	2.027	65	.031		
Total	2.301	68			

Note. * $p < .05$. ** $p < .001$, two-tailed.

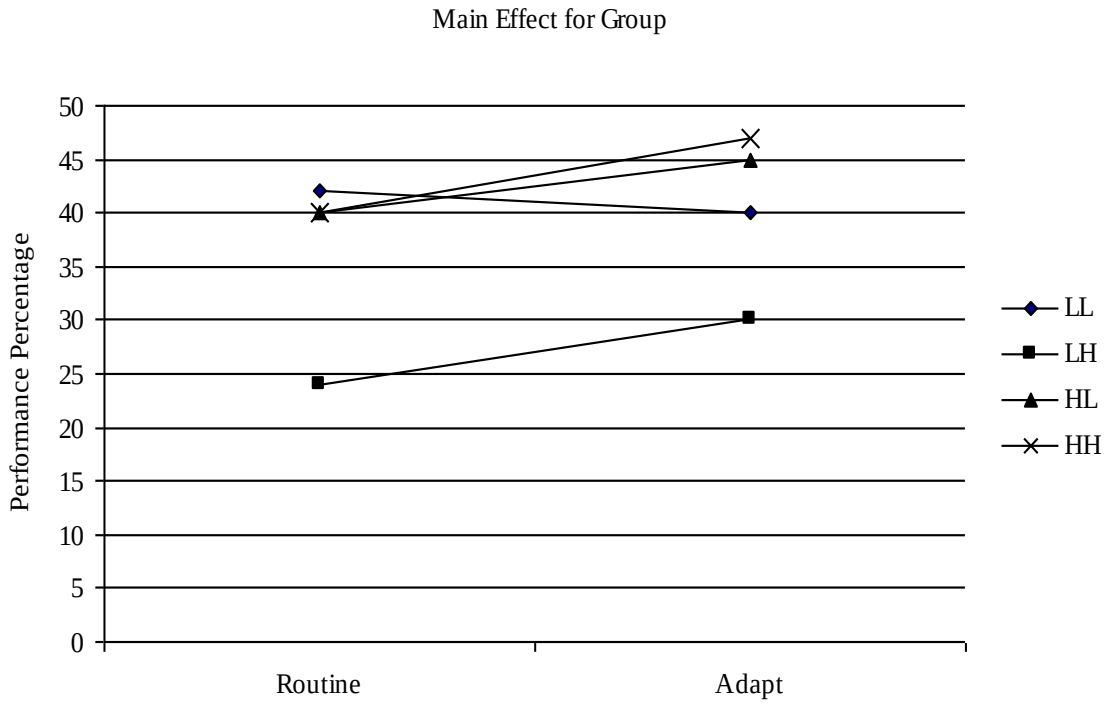

Figure 2. Main Effect for Group F (2, 66) = 4.98, p < .01.
Note. LL = Low GMA, Low Conscientiousness, LH = Low GMA, High Conscientiousness, HL = High GMA, Low Conscientiousness, HH = High GMA, High Conscientiousness

Test for Practice Effects in Second Overload Condition

Using the same median splits, an additional One-Way ANOVA was conducted comparing the mean performance scores of players in the A, B, and C groups on the second overload condition (i.e., second time exposed to an increase in workload similar to the first adapt condition) (see Table 14). Although not directly relevant to answering any of the research questions addressed in this study, the analysis revealed a statistically significant differences F (2, 66) = 4.98, p < .01 in player performance on the second overload condition (see Table 15). Specifically, players in group B (M = .46) performed

significantly ($p < .04$) better than players in group A ($M = .33$) and players in group C ($M = .30$) on the second overload condition.

Table 14

Descriptive Statistics for Performance on the Second Overload Condition

	Variable	*N*	*M*	*SD*
1.	Participant Group A	23	.33	.13
2.	Participant Group B	23	.46	.17
3.	Participant Group C	23	.30	.22

Table 15

Between Subjects ANOVA for Performance in the Second Overload Condition

Source	*Sum of Squares*	*df*	*MS*	*F*	*P*
Between Groups	.322	2	.161	4.982	.010**
Within Groups	2.135	66	.032		
Total	2.457	68			

Note. * $p < .05$. ** $p < .001$, two-tailed.

Difference Scores

To further examine the hypothesized relationships, three One-Way ANOVAs were conducted using the aforementioned groups, with the delta, or difference score. Again, the difference score was an additional variable created to assess any changes in

participants' performance from the routine to adaptive conditions. The results of this analysis found the relationship between the difference score and Cognitive Ability to be non significant F (21, 47) = .640, p = .866 (see Table 16). Along these lines, the results from the second and third analyses did not find a significant relationship with the delta score and Conscientiousness F (35, 33) = .747, p = .802 (see Table 17), or Openness to Experience scores F (31, 37) = .763, p = .778 (see Table 18).

Table 16

Between Subjects ANOVA for Cognitive Ability and Difference Scores

Source	*Sum of Squares*	*df*	*MS*	*F*	*P*
Between Groups	.395	21	.019	.640	.866
Within Groups	1.381	47	.029		
Total	1.776	68			

Table 17

Between Subjects ANOVA for Conscientiousness and Difference Scores

Source	*Sum of Squares*	*df*	*MS*	*F*	*P*
Between Groups	.785	35	.022	.747	.802
Within Groups	.991	33	.030		
Total	1.776	68			

Table 18

Between Subjects ANOVA for Openness to Experience and Difference Scores

Source	*Sum of Squares*	*df*	*MS*	*F*	*P*
Between Groups	.693	31	.022	.763	.778
Within Groups	1.083	37	.029		
Total	1.776	68			

Discussion

The purpose of this study was to determine if a predictive relationship exists between individual differences in Cognitive Ability, Conscientiousness, Openness to Experience and the ability to maintain performance on a changing task. To that end, experimental evidence was found supporting the idea that Cognitive Ability predicts performance across varying levels of workload on the DDD task. The findings of this study partially supported the second hypotheses, that a significant relationship exists between level of Conscientiousness and performance in the adapt condition. More specifically, the results indicate that a negative, rather than positive relationship exists between Conscientiousness and performance in the routine and adapt condition. This finding is contrary to the original hypothesized relationship between these two variables. The results support the idea that Conscientiousness is a viable predictor of performance, but in an unanticipated direction (i.e., negative relationship with performance). Finally, the hypothesized relationship between performance and Openness to Experience was not supported. The practical implications, limitations and directions for future research are discussed below.

Hypotheses

Hypothesis 1 stated that a positive relationship exists between Cognitive Ability and performance in the adapt condition. The results of this study provided empirical support for the first hypothesis. In particular, those participants with high Cognitive Ability performed significantly better on the routine condition and continued this trend into the adapt condition. This finding is consistent with past research that indicates higher Cognitive Ability is positively correlated with both routine (e.g., Cuevas et al., 2004; LePine et al., 1997; Offerman, Bailey, Vasilopoulos, Seal, & Sass, 2004) and adaptive task performance (Bell & Kozlowski, 2002, 2008; Holladay & Quinones, 2003; Kozlowski et al., 2001; LePine et al., 2000; Pulakos et al., 2002; Zaccaro, 2001a). It is also important to discuss the implications of the present findings in relation to the most recent argument in the literature that revolves around the controversial claim that higher levels of General Cognitive Ability may actually impair performance on complex tasks (Beilock & Carr, 2005; Beilock & DeCaro, 2007; DeCaro et al., 2008; Lang & Bliese, 2009). The rationale behind this argument is that participants with higher ability also have additional resources that can be devoted to "over-thinking" a problem (DeCaro et al., 2008). Beilock and DeCaro, (2007) believe that, unlike their higher-ability counterparts, lower-ability performers are more likely to experience "success under stress" because they do not have the working memory capacity to over think a given task (Beilock & DeCaro, 2007, p. 983). In summary, the results of this study did not support the idea that participants with higher-ability experience more difficulty adapting to time pressure (Beilock & Carr, 2005) and changes in a complex task environments (Lang & Bliese, 2009). In fact, the results indicate just the opposite. As previously stated, those

participants with higher ability levels performed significantly higher than in both the routine and adapt conditions.

Hypothesis 2 stated that a positive relationship exists between level of Conscientiousness and performance in the adapt condition. The results provided mixed support for this hypothesis. More specifically, the findings do indicate that a significant relationship exists between Conscientiousness and performance on both the routine and adapt condition. However, the direction of this (negative) relationship is contrary to the original hypothesis stating that the two variables would be positively correlated. Research conducted by LePine, (2000) also found a negative relationship between Conscientiousness and post-decision-making performance following a sudden and unforeseen change in the task context. Supplementary analyses indicated that the negative relationship observed between Conscientiousness and post decision making were driven by facets of Dependability (i.e., order, Dutifulness, and Deliberation). More specifically, LePine found that participants who were Orderly, Deliberate and Self-Disciplined experienced more trouble with decision making after the unanticipated change in task environment. Unfortunately, this relationship cannot be further explored because the present research measured Conscientiousness at the domain rather than facet level.

Interaction between GMA and Conscientiousness

Along these lines, additional analyses revealed a significant interaction between GMA and Conscientiousness. Interestingly, participants with low GMA and high Conscientiousness scores performed significantly worse in the routine and adapt condition. One possible explanation for this finding is that participants with lower GMA may find it difficult to distinguish which information (i.e., game-relevant rules, cues) is

most important. Additionally, individuals high in Conscientiousness would be more likely to devote additional time and energy toward thoroughly understanding all of the rules and requirements of a given task. Generally, those who pay attention to details and are thorough in their work exhibit higher performance. The majority of research on Conscientiousness indicates that there is a positive correlation with performance (Dalton & Wilson, 2000; Davis et al., 2002; Mount et al., 1999). Despite these findings, some researchers assert that in some situations, Conscientiousness might not always be a good thing (Brinkmeyer & McDaniel, 1998; Feist, 1998; Martocchio & Judge, 1997; Tett, 1998; Tett, Jackson, Rothstein, & Reddon, 1999). One example of a situation in which Conscientiousness may prove detrimental to performance is a time sensitive task (Brinkmeyer & McDaniel, 1998; Feist, 1998; Martocchio & Judge, 1997; Tett, 1998; Tett et al., 1999). In this type of fast paced task environment, one cannot afford to dwell too long on a decision before acting. It is possible that participants with lower GMA may have difficultly discriminating which information is most important. Additionally, if these participants are also high in Conscientiousness, they may become hyper focused on the wrong information (Porter, 2005). Those participants who are not able to quickly identify friend or foe, and then immediately act are at a significant disadvantage.

Hypothesis 3 states that a positive relationship exists between level of Openness to Experience and performance in the adapt condition. The results of this study did not, support the third hypotheses. This finding that is not consistent with past research indicating that higher levels of Openness to Experience (Dalton & Wilson, 2000; Davis et al., 2002; Mount et al., 1999), and Conscientiousness (Davis et al., 2002; LePine et al., 2000; Pulakos et al., 2002; Zaccaro 2001a) are positively correlated with individual

performance on a changing task. One possible explanation may be related to the fact that scores on the Openness to Experience measure were highly correlated with Social Desirability Scores. In general, higher scores on Social Desirability indicate that respondents have the tendency to answer each question in a socially desirable manner. In turn, the credibility or the validity of this particular response set (i.e., Openness to Experience Scale) is questionable. Additional research is required to investigate the observed relationship.

Practice Effects

Additional analyses revealed an unexpected main effect for performance from the routine to the adapt condition. There are several potential explanations for this finding. The first possible explanation might be that participants were still learning how to play the simulation game, and as a result the performance continued to increase into the adapt condition. The second potential explanation for the observed increase in mean performance is practice effects. Unfortunately the present research did not control for the order in which players in Groups A, B, and C experienced the adapt condition. Initially, there were no significant differences in mean performance scores among these groups on either the routine or adapt condition. However, on the second overload condition there were significant differences in mean performance as a function of Group (i.e., player in Group A, B, or C). More specifically, players in Group B performed significantly higher (M = 46, SD = .172) than players in either Group A (M = 33, SD = .136) or Group C (M = 30, SD = .22). From these results, one might speculate that a mixture of both practice and exposure to other players performing the DDD task in the adapt condition may be beneficial. It is plausible that the order in which players in Group B experienced each

condition (i.e., practice in adapt condition, observation, practice in the second overload condition) may have facilitated skill acquisition and subsequent performance. For example, players in Group B were exposed to the adapt condition first, and then observed players in Group C experience the condition before being overloaded again, for the second time. Generally, when learning to perform a new task, there is period of time (usually in training sessions) in which participants acquire game relevant skills. The amount of time it takes each participant to acquire these skills and other task related rules may vary. It is possible that players in Group A were overly focused on their own performance, and as a result, they may have been relatively unaware that the other players (i.e., Group B, C) were experiencing sudden increases in workload (i.e., increased number of planes). If this is the case, one could argue that players in Group A did not reap the benefits of experiencing the adapt condition first hand and then observing the performance of others.

Limitations and Future Research

One potential limitation of this study was the sample population, size (n = 69) and the potential generalizability of the laboratory research setting. Unfortunately, due to attrition it was difficult to obtain a large numbers of subjects that had completed all of the required sessions. A total of 223 students participated in the initial session of the study, but only 69 completed the project. Participants were homogeneous in that they were all students attending a university and may not be representative of other populations (i.e., military, organizations). Testing hypotheses using the present task and sample may have reduced the generalization of these results as well. In particular, the fidelity or degree of psychological realism in the experimental task has the potential to influence the

relationships observed. The relatively short amount of time participants spent engaged in the simulation has several implications. Given the short time span, it is highly unlikely that participants developed a strong identity with their roles or experienced the type of pressures similar to those experienced in real-world work environments. Along these lines, the participants' level of investment in the laboratory task and identification with their role in the experiment may have been relatively low. Thus, participants may behave differently than employees in the "field," engaging in personally relevant tasks that have long-term implications. Another potential limitation is the fact that participants were compensated (or received course credit) for their participation rather than for their performance on the task. As a result, there were no real incentives for higher performance. Thus, the findings of this research are limited in terms of external validity and strength in terms of internal validity.

A final limitation of this study that future research should address, concerns the number of practice sessions each participant completed prior to the adapt condition. Because participants experienced only two sessions (i.e., training and routine condition) using the DDD simulation game, it is possible that they were still learning to perform the task throughout the adapt condition. It would have been ideal if researchers had first observed a plateau, followed by a leveling off in performance before introducing the manipulations in workload. Future work should attempt to correct this issue by providing several training sessions in which researchers monitor the participants' performance to determine the most appropriate time to introduce the adapt condition.

Conclusions

Clearly, this area of research has an opportunity to produce knowledge that has real implications that can be used to guide and inform large-scale decision making in both the private and public sectors (e.g., military and organizations selection, classification and development). However, the characteristics (i.e., lack of fidelity in the study setting, task, sample, etc) of this research may constrain the degree to the findings in this study can be used to predict performance of individuals in the field. The findings of this research suggest that additional real world research is required to determine the degree to which the trends established within laboratory research can be generalized and/or applied to real world problems. Future research should investigate the relationships examined in the present study across a more diverse sample and array of tasks.

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Appendix A

Participant Flyer

NEED $$$??

Are you at least 18 years of age? Is English your first language? Is your vision normal or corrected to normal with glasses?

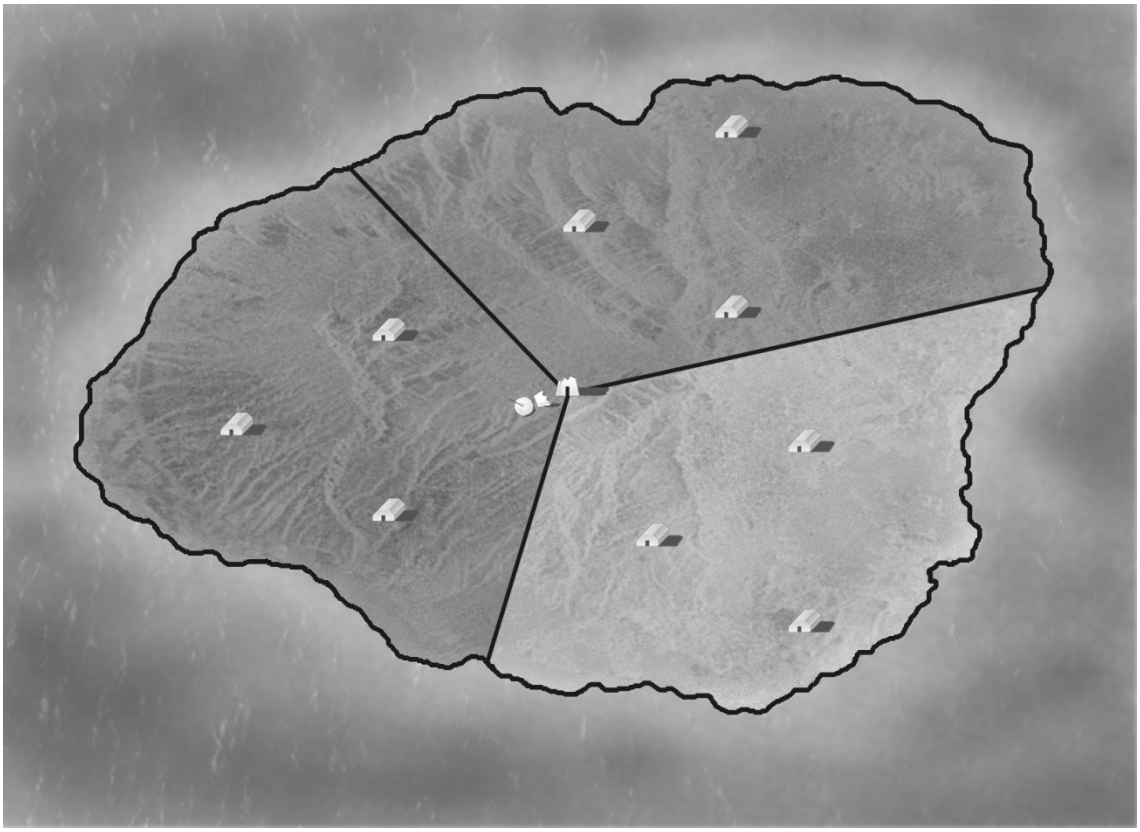
If qualified, earn **$20 ($10/hr for 2 hours) with the opportunity to earn additional $$$** for participating in this psychological experiment.

Total Time Commitment: Up to 2 hours

How do I sign up? Please call 325-3832
between 9:00 a.m. and 5:00 p.m.
Monday through Friday to sign up. Give the code word "team"

Appendix B

Task Environment Screenshot



Appendix C

International Personality Item Pool Items

All items were rated on a five point scale of Very Inaccurate, Moderately Inaccurate, Moderately Accurate, or Very Accurate. Items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24,25, 26, 27, 28, 29 and 30 comprised the overall Openness to Experience trait. Items 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, and 60 comprised the overall trait of Conscientiousness.

1. Do not have a good imagination
2. Have difficulty imagining things
3. Seldom daydream
4. Seldom get lost in thought
5. Enjoy wild flights of fantasy
6. Like to get lost in thought
7. Love to daydream
8. Spend time reflecting on things
9. Do not enjoy going to art museums
10. Do not enjoy watching dance performances
11. Do not like art
12. Do not like concerts
13. Believe in the importance of art
14. Don't understand people who get emotional
15. Feel others' emotions

16. Am passionate about causes

17. Am attached to conventional ways

18. Dislike new foods

19. Don't like the idea of change

20. Avoid difficult reading material

21. Avoid philosophical discussions

22. Can handle a lot of information

23. Enjoy thinking about things

24. Have a rich vocabulary

25. Love to read challenging material

26. Believe in one true religion

27. Believe that too much tax money goes to support artists

28. Believe that criminals should receive help rather than punishment

29. Believe that there is no absolute right or wrong

30. Tend to vote for liberal political candidates

31. Don't understand things

32. Misjudge situations

33. Am sure of my ground

34. Come up with good solutions

35. Complete tasks successfully

36. Handle tasks smoothly

37. Know how to get things done

38. Am not bothered by disorder

39. Leave my belongings around

40. Often forget to put things back in their proper place

41. Do things according to a plan

42. Like order

43. Love order and regularity

44. Want everything to be just right

45. Break my promises

46. Break rules

47. Pay my bills on time

48. Do just enough work to get by

49. Do more than what's expected of me

50. Plunge into tasks with all my heart

51. Set high standards for myself and others

52. Work hard

53. Find it difficult to get down to work

54. Get to work at once

55. Start tasks right away

56. Do crazy things

57. Jump into things without thinking.

58. Often make last minute plans.

59. Rush into things.

60. Stick to my chosen path.